Aura Validation Meeting, 21 – 23 September 2005

Validation of MLS BrO

Nathaniel Livesey

Laurie Kovalenko and other MLS team members.

Ross Salawitch – JPL.

[*livesey@mls.jpl.nasa.gov*]

22nd September 2005

Overview of the EOS MLS BrO observations.

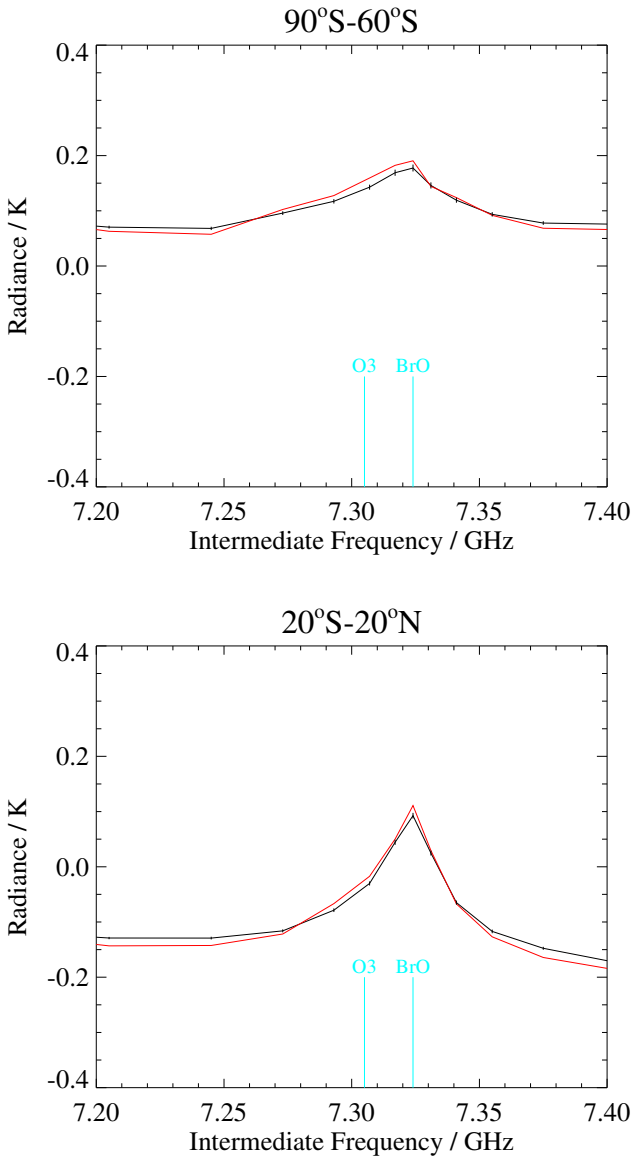
- BrO is the most challenging stratospheric measurement from EOS MLS.
- The sets of BrO spectral lines observed by MLS have about 0.2 K signal.
  - ⇨ Individual MLS radiance observations are made with 2 – 3 K noise.
- Accordingly, some form of averaging is required for useful observations.
- There are three approaches to this problem:
  1. Retrieve individual noisy BrO profiles and average appropriately
     - ⇨ This is the approach taken for v1.51.
  2. Compute average radiance fields and retrieve less noisy BrO profiles from these averages.
     - ⇨ This is the approach taken for an 'interim' BrO product I'll show.
  3. A new algorithm designed for such measurements, performing the averaging in an 'optimal' manner.
     - ⇨ This approach has yet to be implemented.
- The large diurnal variations in BrO allow us to take ascending/descending (mostly day/night) differences to remove some biases.

The v1.51 MLS BrO product

- As for other products, v1.51 MLS BrO is reported as individual profiles.
  - ⇨ Pressure is the vertical coordinate with six surfaces per decade change in pressure over most of the vertical range.
  - ⇨ Profiles are spaced by 1.5° great circle angle (∼24.6 s).
- All the products are produced daily from a single run of the same algorithms.
- While products such as HCl and H_2O have very good signal to noise, BrO profiles have errors of ∼300 pptv, compared to typical values of 10 – 15 pptv.
- We use very loose *a priori* constraints to allow the weak BrO signal to percolate through from the radiances to the level 2 product.
- We apply limited horizontal and vertical smoothing constraints to tune the precision vs. resolution.
- However, as we will see, the amount of vertical smoothing was poorly chosen for v1.51.

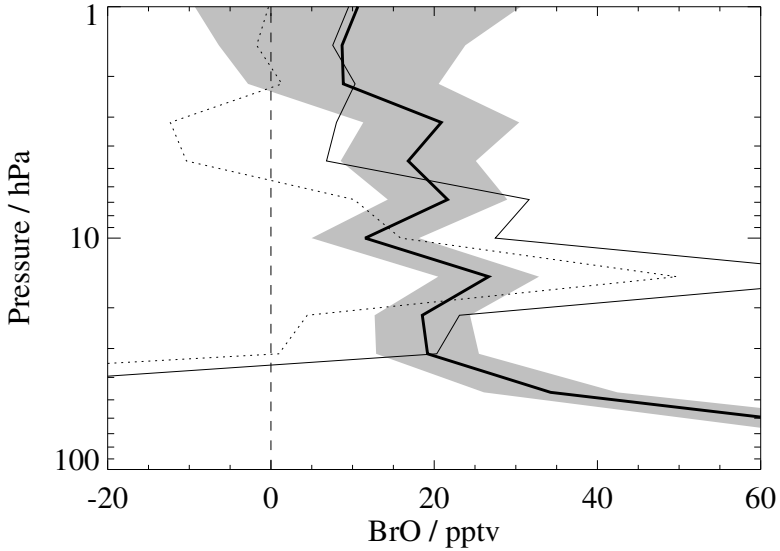
Internal validation for v1.51 — radiances

- Plots show one of the two MLS BrO bands.
- These are ascending/descending radiance differences in the 30–40 km tangent altitude range, averaged for the whole mission.
- Black line is average of the observations, red line is average of the v1.51 fits.
- Taking ascending/descending (mostly day/night) differences clarifies BrO signature.
- Cyan ticks are BrO line and a nearby O_3 line.
- We see that we're fitting radiance observations on average to about 0.02 K.
- Weaker signature 90°S–60°S expected:
  - ⇨ Generally less BrO in polar regions.
  - ⇨ Polar day/polar night suppresses ascending/descending variation.



Internal validation for v1.51 — 'sanity checks'

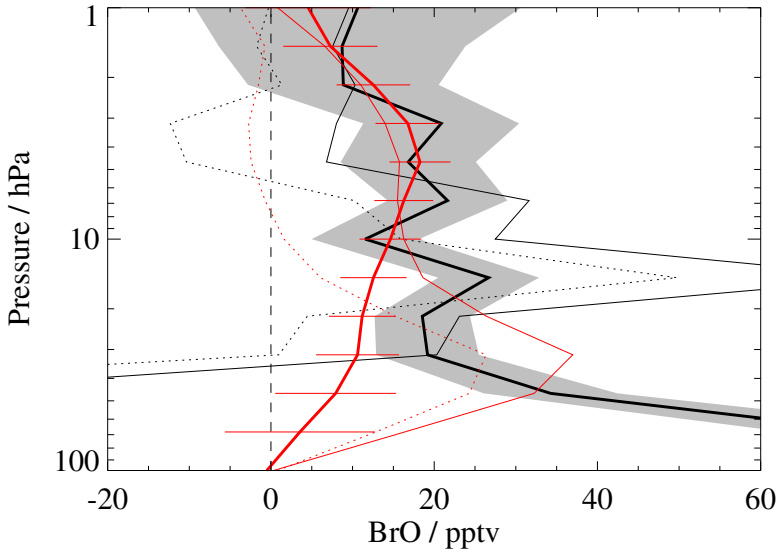
- Plot shows average v1.51 BrO for January 2005 over 30°N–40°N.
- Thin solid line is ascending (daytime).
- Dotted line is descending (nighttime).
- Thick line is ascending/descending difference with shading showing precision of this monthly mean.



- The observed diurnal behavior is expected, with more BrO in the day.
- The ascending/descending values seem reasonable in the upper stratosphere.
- However, in the mid- and lower stratosphere, the values seem too large.
- Even asc/des differences show unreasonable values in lower stratosphere.
- Overall, the data only look 'OK' over 10–2.2 hPa.
- The vertical 'oscillations' and large noise are hindering scientific study.
- V1.51's preference for vertical resolution over precision was probably unwise.

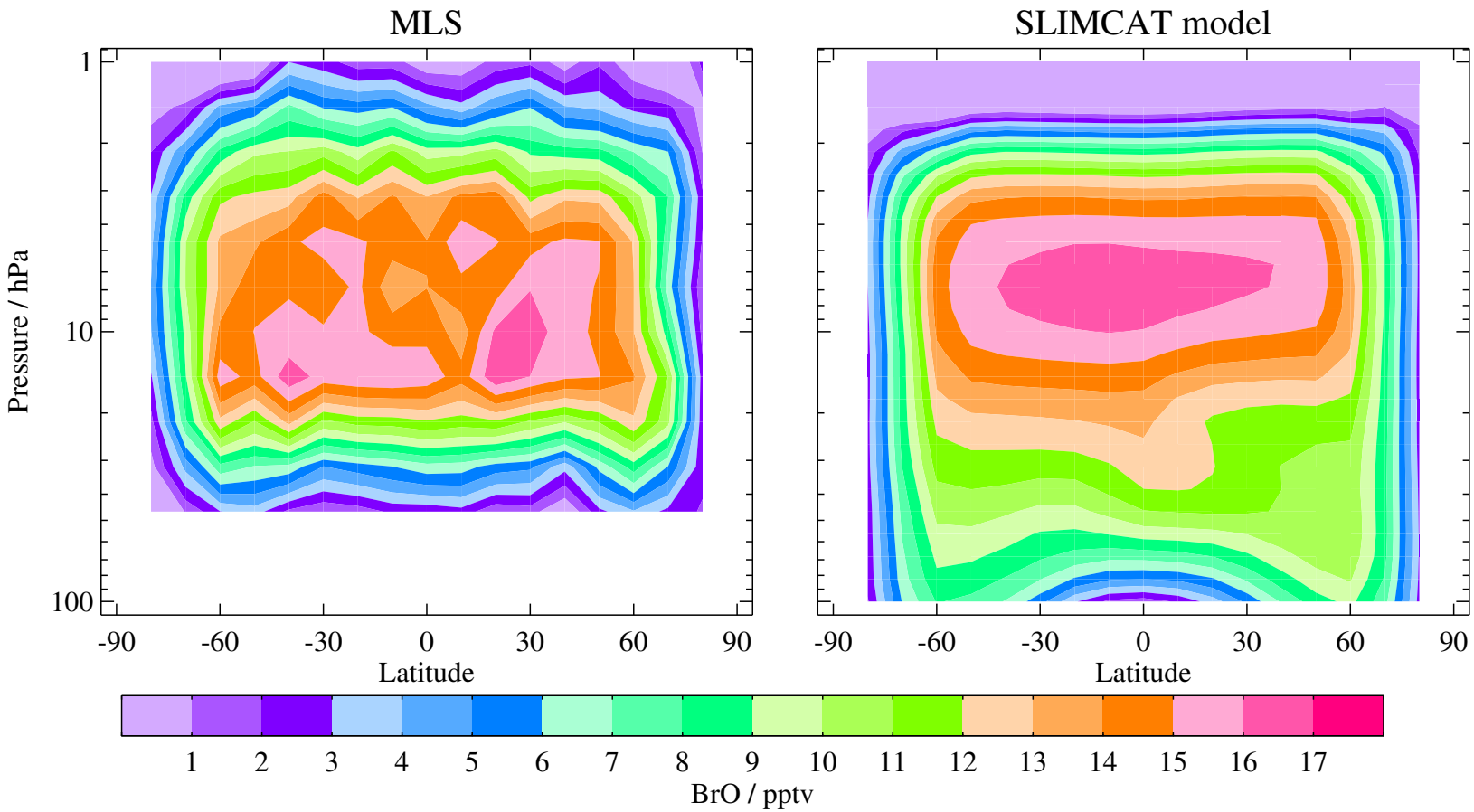
An interim BrO product

- To alleviate these issues, I have made an 'interim' BrO product.
- This directly retrieves daily zonal means from averaged radiance fields.
- These daily zonal means are then averaged together.
- This is shown as the red line on the new plot (still January 2005, 30°N – 40°N).



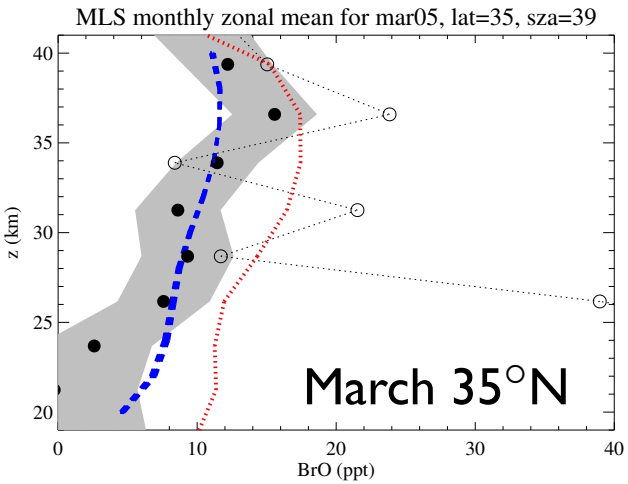
- We see smoother, more precise (lower vertical resolution) profiles.
  - ⇨ We chose ~6 km vertical resolution for this product.
- Improvements are seen both in the differences and the individual ascending/descending averages.
- These 'cautious' retrievals only use radiances down to 46 hPa.
- The lower limit of the vertical range of this product remains to be investigated.

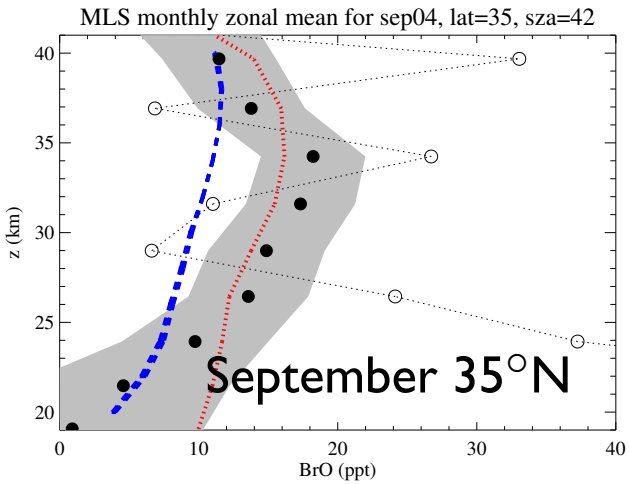
Comparison to the SLIMCAT model

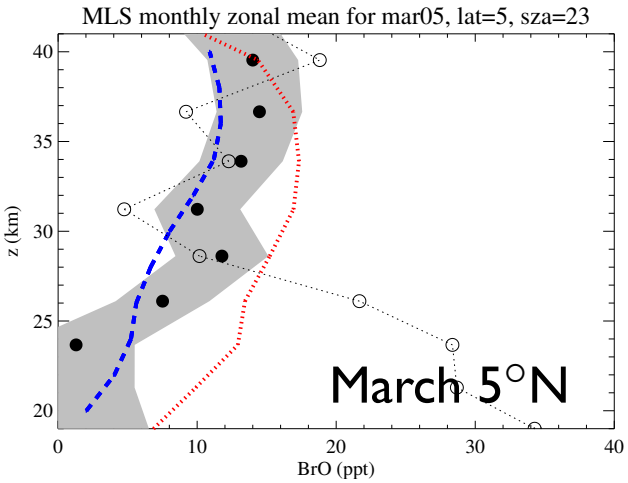


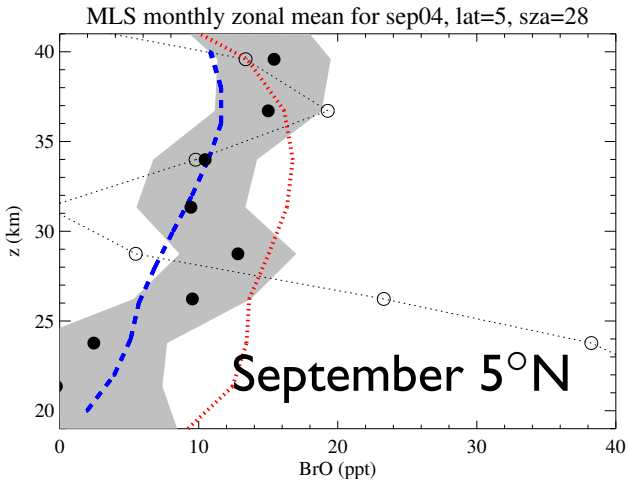
- Plot shows zonal mean ascending/descending difference for MLS interim BrO and SLIMCAT model for the whole MLS mission to date.
- The SLIMCAT model is run in 'near real time', sampled to the MLS profile locations.
- MLS shows smaller values than SLIMCAT in the peak region, but often larger values elsewhere.
- The disagreement in the lower stratosphere probably reflects a fall-off in MLS sensitivity.

Comparisons to a box model









- Black circles with shading are 'interm' BrO averages.
- Dotted black with open circles is v1.51 BrO.
- Red line is SLIMCAT model (22 pptv total bromine).
- Blue line is box model assuming WMO conditions (16 pptv bromine).

- Plots show selected comparisons of MLS with box model output.
- This is preliminary work, we need to constrain the model better to other MLS observations (to get NO_x etc., correct).

Conclusions and future work

- The v1.51 product shows generally reasonable behavior.
- However the levels of noise make its scientific use challenging.
- Version 2.0 will address this problem.
- An interim BrO product shows more encouraging results.
- We plan further comparisons with models.
- Also some comparisons with SCIAMACHY data.
  - ⇨ Though two different sets of this exist to date.
- Some comparisons with *in-situ* observations will be undertaken.
  - ⇨ Though definitive conclusions will be hard to draw from a comparison of a single profile to a monthly zonal mean.
- All of these comparisons will need to involve model calculations to handle the differences in solar time.